DOE/EIS-0245/SA1

Supplement Analysis

Supplement Analysis of Environmental Effects of Changes in DOE's Preferred Alternative for Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington

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List of Acronyms and Abbreviations

CFR	Code of Federal Regulations
CSB	Canister Storage Building
CVD	cold [50 ^{o}C] vacuum drying
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
FEIS	Final Environmental Impact Statement
FR	Federal Register
KE	K-East Basin
KW	K-West Basin
kg	kilogram(s)
kPa	kiloPascal(s)
lb	pound(s)
MCO	Multi-Canister Overpack
mrem	millirem [1/1000th of a rem]
MWh	megaWatt-hour(s)
NEPA	National Environmental Policy Act
psig	pounds per square inch gauge
rem	Roentgen equivalent-mankind
ROD	Record of Decision
SNF	Spent Nuclear Fuel
Sv	Sievert(s) [1 Sv = 100 rem]

INTRODUCTION

DOE prepared and issued a final environmental impact statement (FEIS) on the "Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington" (DOE/EIS-0245F) in January 1996 [DOE 1996]. A notice of availability of the FEIS was published in the Federal Register on February 2, 1996 (61 FR 3932). The FEIS evaluated the potential environmental impacts of alternatives for managing the spent nuclear fuel (SNF) located in the K-East (KE) and K-West (KW) SNF storage basins at the Hanford Site located in southeastern Washington State.

Based on the analysis in the FEIS and after careful evaluation of environmental impacts, costs, compliance requirements, engineering considerations, worker and public health and safety, and public, agency and tribal comments, DOE decided to implement the preferred alternative evaluated in the FEIS, with two modifications, and documented that decision in the Record of Decision (ROD). The ROD was published in the Federal Register on March 15, 1996 (61 FR 10736).

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The preferred alternative described in the ROD consists of removing the SNF from the basins, vacuum drying, conditioning and sealing the SNF in inert-gas filled canisters for dry vault storage in a new facility, to be built at Hanford, for up to 40 years pending decisions on ultimate disposition. The K Basins will continue to be operated during the period over which the preferred alternative is implemented. The preferred alternative also includes transfer of the basin sludge to Hanford's double-shell tanks for management, disposal of non-SNF basin debris in a low-level burial ground at the Hanford Site, disposition of the basin water, and deactivation of the basins pending decommissioning.

The two modifications to the FEIS in the ROD were with respect to management of the sludge, and the timing of placement of the SNF into the transportation casks. The modification for management of the sludge was that should it not be possible to put the sludge into the double-shell tanks, the sludge would either continue to be managed as SNF, or disposed of as solid waste. The modification regarding placement of the SNF into the transportation casks was to reduce the radiation exposure to the workers by placing the Multicanister Overpacks (MCOs) inside the transportation casks before the SNF is loaded into the MCOs, instead of loading the SNF into the MCOs prior to placing them inside the transportation casks.

In the ensuing two years since the Record of Decision was published, a large number of process design analyses have been completed and characterization data have been obtained that better describes the chemical and physical properties of the fuel and sludge in the K Basins. This information resulted in a reassessment of the SNF drying process that lead to the conclusion that the hot conditioning/passivation step would not provide a benefit commensurate with the risk associated with heating the SNF to high temperature.

Section 1502.9(c) of the Council on Environmental Quality Regulation for Implementing the Procedural Provisions of NEPA, 40 CFR Parts 1500-1508, requires the preparation of a Supplemental Environmental Impact Statement if (1) the agency makes substantial changes in the proposed action that are relevant to environmental concerns; or (2) there are significant new circumstances or information relevant to environmental concerns and bearing on the proposed action or its impacts. Section 1021.314(c) of the DOE NEPA Regulations (10 CFR 1021, 61 FR 64603, December 6, 1996) provides that, where it is unclear whether a Supplemental EIS is required, DOE will prepare a Supplement Analysis to support a DOE determination with respect to the criteria of 40 CFR 1502.9(c). The purpose of this Supplement Analysis is to provide a basis for a determination of whether or not a Supplemental EIS is required as a result of deleting the hot conditioning/passivation step from the preferred alternative selected in the Record of Decision.

Preferred Alternative as Originally Proposed

The preferred alternative is referred to in the FEIS as "drying/passivation (conditioning) with dry vault storage". As noted in the FEIS, the details of the proposed processes and perhaps their order were expected to change somewhat as the designs evolved and as the results of ongoing characterization testing became available. However, the impacts of the steps described in the FEIS and the ROD bounded those necessary to place the K Basins SNF in safe dry storage. The proposed series of operations to achieve the preferred alternative as described in the ROD, with the modifications described in the ROD, was as follows:

- Continue K Basin operations until the removal of SNF, sludge and debris, and disposition of the water is completed. Make modifications to the K Basins, as necessary, for maintenance, monitoring and safety, and provide systems necessary to support the activities described below.
- Remove K Basin SNF from existing canisters, clean and desludge.
- Repackage the SNF into fuel baskets designed for MCO dimensions, that would include provision for water removal, SNF conditioning requirements, and criticality control.
- Place the empty MCOs in their transportation casks.
- After loading the SNF into the MCOs in their casks and draining the MCOs, dry the SNF under vacuum at approximately $50^{o}C$ ($120^{o}F$), flood the MCOs with inert gas and seal penetrations.

- Transport the SNF (in MCOs) in these casks via truck to the Canister Storage Building (CSB) site in the 200 East Area and, after removing them from the casks, provide for temporary vented staging, as necessary.
- Further condition the SNF in MCOs, as soon as practicable, heating the SNF in a vacuum to about 300°C (570°F) to remove water that is chemically bound to the SNF and canister corrosion products, and to dissociate, to the extent practicable, any reactive uranium hydride present.
- Following conditioning, weld-seal the SNF in an inert gas in the MCOs for dry interim storage in a vault for up to 40 years.
- Collect and remove the sludge from the basins and disposition as waste in Hanford's double-shell tanks. Should it not be possible to put the sludge into the double-shell tanks, the sludge will either continue to be managed as SNF, or disposed of as solid waste.
- Collect the non-SNF debris from the basins and dispose of as low-level waste in Hanford's existing low-level waste burial grounds.
- Remove and transport basin water to the 200 Area Effluent Treatment Facility for disposal at the 200 Area State-Approved Land Disposal Site.
- Prepare the K Basins for deactivation and transfer to decontamination and decommissioning program.

Proposed Change to the Preferred Alternative

The principal change to the preferred alternative is the deletion of the conditioning/passivation step. This step is described in the FEIS and the ROD as "further condition the SNF in MCOs, as soon as practicable, heating the SNF in a vacuum to about 300°C (570°F) to remove water that is chemically bound to the SNF and canister corrosion products, and to dissociate, to the extent practicable, any uranium hydride present." The revised series of operations to transition the K Basins SNF from wet to dry storage, including changes that have occurred as the design of the MCO has evolved, is as follows:

- Continue K Basin operations until the removal of SNF, sludge and debris, and disposition of the water is completed. Make modifications to the K Basins, as necessary, for maintenance, monitoring and safety, and provide systems necessary to support the activities described below.
- Remove K Basin SNF from existing canisters, clean and desludge.
- Repackage the SNF into fuel baskets designed for MCO dimensions, that would include provision for water removal, SNF conditioning requirements, and criticality control.
- Place the empty MCOs in their transportation casks.
- After loading the SNF into the MCOs in their casks and installing a mechanical seal, drain the MCOs, dry the SNF under vacuum at approximately 50°C (120°F), flood the MCOs with inert gas and seal penetrations.
- Transport the SNF (in sealed MCOs) in these casks via truck to the Canister Storage Building (CSB) site in the 200 East Area.

- At the CSB, remove the MCOs from the transportation casks, weld-seal a final cover on the MCOs containing the SNF in an inert gas and place the MCOs in dry interim storage in a vault for up to 40 years.
- Collect and remove the sludge from the basins and disposition as waste in Hanford's double-shell tanks. Should it not be possible to put the sludge into the double-shell tanks, the sludge will either continue to be managed as SNF, or disposed of as solid waste.
- Collect the non-SNF debris from the basins and dispose of as low-level waste in Hanford's existing low-level waste burial grounds.
- Remove and transport basin water to the 200 Area Effluent Treatment Facility for disposal at the 200 Area State-Approved Land Disposal Site.
- Prepare the K Basins for deactivation and transfer to decontamination and decommissioning program.

Original Purpose of Conditioning/Passivation Step and Why it Can be Deleted

The reason for including the (hot) conditioning/passivation step in the original preferred alternative was twofold. First, the conditioning process, which involved heating the fuel to a higher temperature than is attainable in the Cold Vacuum Drying (CVD) facility, was intended to remove more of the chemically-bound waters of hydration than could be achieved by CVD alone. This would reduce the maximum pressure that could be attained in the MCO. Second, the purpose of the passivation process was to destroy any uranium hydride and uranium fines that might be present by exposing them, at high temperature, to a controlled amount of oxygen. This would lessen the concern for an air ingress accident by removing essentially all of the most susceptible pyrophoric materials. These steps are discussed in more detail below.

Conditioning Step

The purpose of the conditioning step was to reduce the water inventory in the MCO to as low as practicable since water, in any form, is the principal source of gas, and therefore pressure, in the MCO. Water can be present in the MCO in three forms: residual free water, chemically bound water and chemisorbed water.

- Residual free water is that remaining in the MCO after the cold vacuum drying process. This will be a small amount, perhaps in capillaries or small inaccessible pockets, that does not manifest its presence during the pressure rebound test that determines the completion of drying.

- Chemically bound water is water in the form of hydrates of various oxides (principally uranium oxides) produced by corrosion of the exposed uranium and other metals present in the basin during the wet storage period. These oxides can be on the fuel surfaces or in any of the sludge entrained with the fuel when it is placed into the MCO.
- Chemisorbed water exists on all wetted surfaces of all materials within the MCO. This is water bound to the surfaces by forces that are much stronger than the normal (van der Waals) forces between molecules. A much higher temperature, well beyond the conditioning temperature of 300 ^oC (570 ^oF), is required to release chemisorbed water. While chemisorbed water cannot practically be removed, it requires an extremely large surface area to accumulate an amount sufficient to have any appreciable impact on the pressure in the MCO.

There are two means by which gas can be produced from water in the MCO. Free water or water vapor can react with exposed uranium to form uranium dioxide and hydrogen gas. <u>All</u> forms of water can undergo radiolysis, producing hydrogen and oxygen gases in the process. Therefore, each mole of water present in the MCO in any form can ultimately produce one mole of hydrogen gas, either through reaction with exposed uranium or by radiolysis. In addition, water that is consumed by radiolysis results in the production of another one-half mole of oxygen gas. Both processes will occur in the MCO (that is, not all water will be consumed by radiolysis), but for analysis purposes it was assumed that each mole of water in any form present in the MCO when it is sealed will ultimately yield 1.5 moles of gas.

Other potential sources of gas in the container (fission products such as krypton or xenon liberated from the fuel in the corrosion process, helium formed from alpha emitters in the fuel and sludge, and radiolysis of any hydrocarbons that may be present; e.g., residual cutting oil on the container surfaces or contaminants in the sludge) are negligible compared to that from the water that may credibly be present.

Characterization measurements [PNNL 1997] of the drying behavior of actual K Basins sludge showed that conditioning at 300 ^{o}C (570 ^{o}F) would remove most of the bound water of hydration left after cold vacuum drying. Only a small amount would remain that, through radiolysis, would produce a small amount of gas. However, there is no practical way to verify the amount of bound water in an MCO at the start of vacuum drying, nor is it possible to measure the bound water remaining after either cold vacuum drying or hot conditioning. The safety case must, therefore, conservatively bound the amount of water that might be present in an MCO at the time it is sealed, and take no credit for removal of bound water.

Safety basis calculations [DESH 1997] using extreme values for all parameters that affect pressure conclude that the maximum pressure that can be attained in an MCO, over the 40 year interim storage period following cold vacuum drying, is 916 kPa (133 psig). The expected maximum pressure is considerably less, about 365 kPa (53 psig). These calculations take no credit for removal of any bound water in CVD, nor would they take credit for any bound water removed in the hot conditioning process if it were done. Thus, while the hot conditioning process would decrease the maximum attainable pressure in the MCO by reducing the amount of water, it would carry the risk of a fuel fire associated with heating the uranium fuel to the higher temperature and would not allow a reduction in the MCO design pressure.

To provide a safety margin to allow for the presence of as-yet-unidentified water-bearing substances in the sludge, and to accommodate process errors, the safety approach has been to modify the design of the MCO to accommodate the maximum design pressure rating attainable without major changes in the MCO dimensions or materials. Small changes in the MCO hardware design (principally a small increase in the thickness of the bottom head) have resulted in an increase in its design pressure from 1,034 kPa (150 psig), as originally configured, to 3,101 kPa (450 psig).

Passivation Step

The inclusion of a passivation step in the preferred alternative was based on an early analysis of the French conditioning process for metallic fuel. The French process was developed to destroy uranium hydride and uranium fines to account for an accident scenario in which a failure of the fuel container occurred during transportation over public roads. Such a failure would allow air to enter the container and react with these pyrophoric materials, resulting in a fuel fire. For Hanford's metallic uranium fuel, this type of container failure has been demonstrated [WMFS 1997] to be incredible (less than 10^{-6}) by the subsequent robust design of the MCO transportation cask and the transportation and storage processes. The analyses detailed in [WMFS 1997] show that the MCO cask maintains leak-tight containment of the SNF through all normal transfer and accident conditions, including drops and a fully engulfing fire. Analyses have also been done for drops of the MCO outside of the transportation cask, at the CSB. These analyses show that in no case is the MCO breached as a result of the drop. Consequently, an air ingress accident is not credible and it is not necessary to destroy uranium hydride or uranium fines.

Furthermore, as noted above, some tightly bound water would have remained in the MCO following hot conditioning. This water would undergo radiolysis over time, producing oxygen and hydrogen gas. Since the hydrogen can react with any exposed uranium in the container to form uranium hydride, and the oxygen could react with some of the existing uranium hydride to produce uranium fines, the passivation process would only temporarily remove these materials. Consequently, air would have to be precluded from entering the MCO following processing even if the hot conditioning/passivation step were performed.

Absent the requirement for the accommodation of the container rupture accident, the inclusion of the passivation process does not significantly improve the condition of the fuel with respect to performance during interim storage.

Elimination of the passivation process, however, reduces system complexity, eliminates potential accident scenarios and results in cost savings for the Project.

Impact of Change to Preferred Alternative

Among the purposes of an Environmental Impact Statement is a requirement that it provide a full and fair discussion of significant environmental impacts of the alternatives considered and that these impacts be used, together with other relevant information, in the decision making process. This section presents a review of the effects of the change to the preferred alternative on the factors that were considered in the EIS. In each of the paragraphs below, the impact of the change in the preferred alternative on the factor addressed in the paragraph with the same title in Section 5 of the EIS [DOE 1996] is described.

Land Use.

Since hot conditioning was to done within the CSB, and the CSB "footprint" is not affected, the change to the preferred alternative has no impact on land use as analyzed in the EIS.

Socioeconomics.

A small decrease in employment and population impacts related to construction and operation of the hot conditioning facility would be expected relative to the EIS analyses.

Cultural Resources.

The change to the preferred alternative has no impact on cultural resources as analyzed in the EIS.

Aesthetic and Scenic Resources.

The change to the preferred alternative has no impact on aesthetic and scenic resources as analyzed in the EIS.

Geologic Resources.

The change to the preferred alternative has no impact on geologic resources as analyzed in the EIS.

Air Quality and Related Consequences: Radiological Consequences.

Deletion of the hot conditioning step means that the fuel will not be heated under vacuum a second time. As a result, the potential for radiological emissions associated with the normal safe operation of the hot conditioning equipment will also be eliminated.

Air Quality and Related Consequences: Nonradiological Consequences.

Deletion of the hot conditioning step means that the fuel will not be heated under vacuum a second time. As a result, the potential for non-radiological emissions associated with the normal safe operation of the hot conditioning equipment will also be eliminated.

Water Quality and Related Consequences.

The change to the preferred alternative has no impact on water quality and related consequences as analyzed in the EIS.

Ecological Resources.

The change to the preferred alternative has no impact on ecological resources as analyzed in the EIS.

Noise.

The change to the preferred alternative has no impact on noise as analyzed in the EIS.

Transportation.

The change to the preferred alternative has no impact on transportation as analyzed in the EIS.

Occupational and Public Health and Safety - Radiological Consequences to the Public.

Deletion of the hot conditioning process from the preferred alternative reduces the potential to release radioactive materials to the environment, whether from the normal hot conditioning operation or because of an accident that could occur during hot processing.

Occupational and Public Health and Safety - Radiological Consequences to Workers.

In addition to the reduction in the potential release of radioactive materials to the environment brought about by eliminating the hot conditioning process from the preferred alternative, the direct exposure of workers to radiation from the MCOs is also reduced. Any worker dose that would have been received during the additional handling steps required to conduct the hot conditioning step is eliminated.

Occupational and Public Health and Safety - Nonradiological Consequences to the Public and to Workers.

Deletion of the hot conditioning process from the preferred alternative reduces the risk of occupational injuries and illnesses.

Site Services.

Elimination of the hot conditioning step in the fuel drying process results in a reduction in the utility and energy usage associated with the preferred alternative. A conservative estimate is that approximately half of the 6,800 MWh/yr of electricity consumption estimated [DOE 1996] for the drying facilities would not be required. Over the approximately two-year operating period, then, 6,800 MWh of electricity would be saved. Similarly, helium usage would be reduced by at least half each year, saving approximately 160 kg (355 lb) of helium, and argon usage would be curtailed, saving about 40,000 kg (88,800 lb) of that gas. No oxygen would be required for operations, eliminating the need for 1,000 kg (2,220 lb) of oxygen/yr.

Waste Management.

The change to the preferred alternative has no impact on waste management as analyzed in the EIS.

Facility Accidents.

The most serious accident associated with the preferred alternative is a loss of control of the drying/passivation process in which the fuel in the MCO rapidly oxidizes. The associated release of radioactive particles could, in the "worst case" scenario evaluated in the EIS, result in a maximum individual dose of 0.02 Sv (2 rem) to the offsite resident. The collective dose to the population could result in less than one to as many as 32 latent cancer fatalities if the accident occurs and no protective action is taken. Vacuum drying was to be done at both the Cold Vacuum Drying Facility and at the CSB (hot conditioning) in the preferred alternative; however, a fire is more likely at the CSB than at the CVD Facility because the process at the CSB involves heating the fuel to 300 ^{o}C as compared to 50 ^{o}C at the CVD Facility. Therefore, eliminating hot conditioning reduces the probability that this serious accident would occur.

Cumulative Impacts Including Past and Reasonably Foreseeable Actions: Land Use, Geological Resources and Ecological Resources.

The change to the preferred alternative has no impact on this consideration as analyzed in the EIS.

Cumulative Impacts Including Past and Reasonably Foreseeable Actions: Air Quality.

Deletion of the hot conditioning process from the preferred alternative reduces the potential for air emissions and, consequently, the potential cumulative impact on air quality.

Cumulative Impacts Including Past and Reasonably Foreseeable Actions: Waste management.

The change to the preferred alternative has no impact on this consideration as analyzed in the EIS.

Cumulative Impacts Including Past and Reasonably Foreseeable Actions: Socioeconomics.

The change to the preferred alternative has no impact on this consideration as analyzed in the EIS.

Cumulative Impacts Including Past and Reasonably Foreseeable Actions: Occupational and Public Health.

Deletion of the hot conditioning process from the preferred alternative reduces the risk of occupational injuries and illnesses.

Adverse Environmental Impacts that Cannot be Avoided.

The change to the preferred alternative has no impact on this consideration as analyzed in the EIS.

Relationship Between Short-Term Uses of the Environment and the Maintenance and Enhancement of Long-Term Productivity.

The change to the preferred alternative has no impact on this consideration as analyzed in the EIS.

Irreversible and Irretrievable Commitment of Resources.

The change to the preferred alternative has no impact on irreversible and irretrievable commitment of resources as analyzed in the EIS.

Potential Mitigation Measures.

The strengthened MCO eliminates over pressurization accidents; otherwise, the change to the preferred alternative has no impact on potential mitigation measures as analyzed in the EIS.

Environmental Justice.

The change to the preferred alternative has no impact on environmental justice as analyzed in the EIS.

Estimated 40-Year Storage and Life-Cycle Costs.

Elimination of the hot conditioning step in the fuel drying process results in a reduction of about $31 Million in the life-cycle cost for the preferred alternative. Part of this reduction is the decrease in Site Services already noted. The remainder is associated with deletion of the equipment associated with the hot conditioning/passivation step and omission of the safety analysis and procedure preparation work supporting its operation.

References

DESH (Duke Engineering and Services-Hanford) 1997. *K Basins Particulate Water Content, Behavior and Impact*, HNF-1523, Rev.0, November 1997.

DOE (U.S. Department of Energy) 1996. *Management of Spent Nuclear Fuel from the K Basins at the Hanford Site, Richland, Washington*, DOE/EIS-0245F, January 1996.

PNNL (Battelle - Pacific Northwest National Laboratory) 1997. *Drying Behavior of K-East Canister Sludge*, PNNL-11628, December 1997.

WMFS (Waste Management Federal Services) 1997. *Safety Analysis Report for Packaging (Onsite) - Multicanister Overpack Cask*, HNF-SD-TP-SARP-017, Rev. 0, July 1997.

Determination

Deletion of the hot conditioning/passivation step from the preferred alternative for the management of spent nuclear fuel from the K Basins at the Hanford Site does not result in potential environmental impacts that are significantly different from those analyzed in the FEIS. Changes in the impacts associated with elimination of this step either reduce or do not affect the environmental impact of the preferred alternative. Therefore, no additional NEPA analysis is required under 10 CFR Part 1021 or 40 CFR Parts 1511-1508.

Signed in Richland, Washington this 28th day of August, 1998, for the U.S. Department of Energy.

(Original signed by)

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